The Ten-Turn "Chopstick" Helical: A High Gain Antenna for Satellite Work

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Forward gain, forward gain, forward gain: that's the ceaseless search in satellite work. It's a task that jumps to the forefront with the approach of a new breed of satellite — Phase IIIA.

Phase IIIA will be put into a "pseudo-synchronous" orbit — which means that it will offer many of the advantages of commercial synchronous satellites. It will swing around the bottom of the globe at a low perigee of 1500 km and then hurtle out to an apogee of 36000 km — and (here's the bonus) — its movement relative to an earth station for the 4 hours spanning this apogee will be small. So that for 4 hours there will be an almost-stationary satellite up there, covering half the globe. For the first time, radio amateurs will be able to communicate on a world-wide basis using VHF + UHF, thus skipping many of the baneful problems of HF propagation. What's more, Doppler shift at the apogee will be very slight — so that the skilful searching and re-tuning so essential with low-orbit satellites will no longer be required.

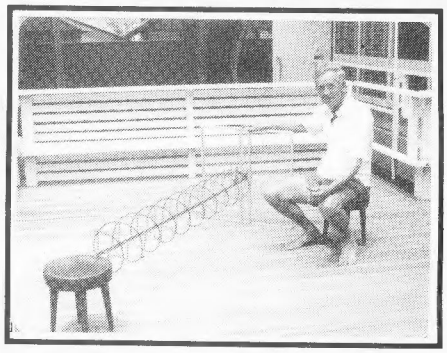


PHOTO 1: Colin 9M2CR with the completed project.

But there is a price to be paid for these advantages! Path length at apogee is virtually the same as that for commercial synchronous satellites. **They** counter this path loss by using giant 30-metre dishes, and low-noise amplifiers on receive, cooled in liquid helium. No amateur can compete with this! But latest estimates for Phase IIIA suggest that we can get by with an ERP of 500 watts — a tolerably modest figure. Of course, a 500 watt final is out of the question for most amateurs — so we have to get our gain elsewhere — notably from the antenna system.

Phase IIIA Uplink will be centred on 435.215 MHz, and will require clockwise circular polarisation. So — how to make a high-gain antenna with circular polarisation which can be hoisted into the air and pointed in the right direction without too much trouble? That is the question. Long John Yagis — crossed and phased — could offer one solution: but at 435 that phasing harness could present problems, while impedance matching is also a chore.

So . . . why not a helical? Here we have neatness, high gain, wide bandwidth and circular polarisation — all in one. Scanning the handbooks for design info on helicals showed that a ten-turn helix looked promising: a gain of 15 dB would persuade my 10-watts output to masquerade as 300 watts, and a beam-width of 36 degrees ought not to be too finicky to point. The boom length at 435 MHz would be about 6 feet, with a reflector 28 inches square — these seemed manageable dimensions. But what to use for the helix, how to form it, how to keep it in shape? All pertinent questions at this particular QTH — with the nearest parts or material stores some 70 miles away.

The boom was no problem. A 6 ft. 4 in. length of 1 by ½ in. meranti timber, good and straight, looked just about right — with the 1 in. edge vertical to avoid any bending (as it happened, the antenna itself turned out to be feather-light and easily supported by the 1 by ½). But what about the helix, and what about the spacers?

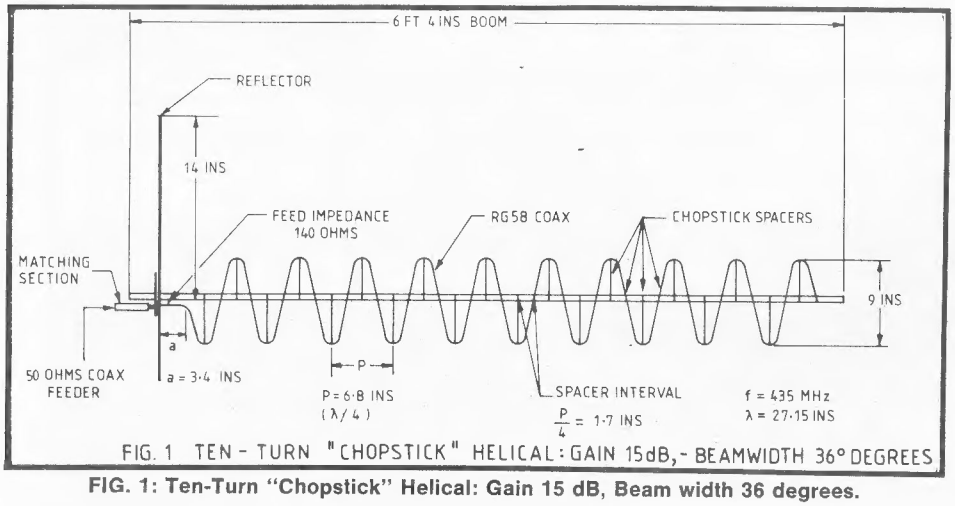


FIG. 1: Ten-Turn "Chopstick" Helical: Gain 15 dB, Beam width 36 degrees.

Copper tubing was unobtainable: in any case it would have been expensive, heavy and difficult to shape. Someone, somewhere had mentioned using coaxial cable: so why not RG58? The outer screen would simulate a tubular conductor: the inner conductor is not needed but could be soldered to the screen at each end. Good grade coax has a tinned, close-mesh screen with an excellent weatherproof sheath. What could be better? We promptly hunted out a 25 foot length.

Spacers were now the problem. Most handbooks showed 3 spacers per complete turn of the helix, each spacer being set at a 120-degree angle to the last. Since the boom was rectangular, it seemed more sensible to opt for 4 spacers per turn, and to put them at 90-degree settings. The original plan was to use ¼ in. diameter plastic rod or wood dowel for the spacers, but nothing remotely resembling such material was available locally. Pondering the problem over a tasty meal of Fuyong egg, crispy chicken and Cantonese bean curd — I suddenly saw the answer — there in my right hand: chopsticks! Why not?

Chopsticks are available in a wide variety of designs and material in Malaysia: we chose simple, wooden, everyday chopsticks (not bamboo) — undecorated — sold in bundles of 20 to 25 US cents a bundle. As with most chopsticks, the lower half is of circular, tapered cross-section — merging into a rectangular shape for the upper half. It couldn't be better! We marked the boom at 1.7 in. intervals and drilled holes 3/16 in. diameter — consecutively at right angles for its entire length. The boom was long enough to allow 3 to 4 in. to stick through the reflector, for clamping purposes. A 3.4 in. piece of the same boom material (1 by ½) was fixed to the boom at the reflector end.

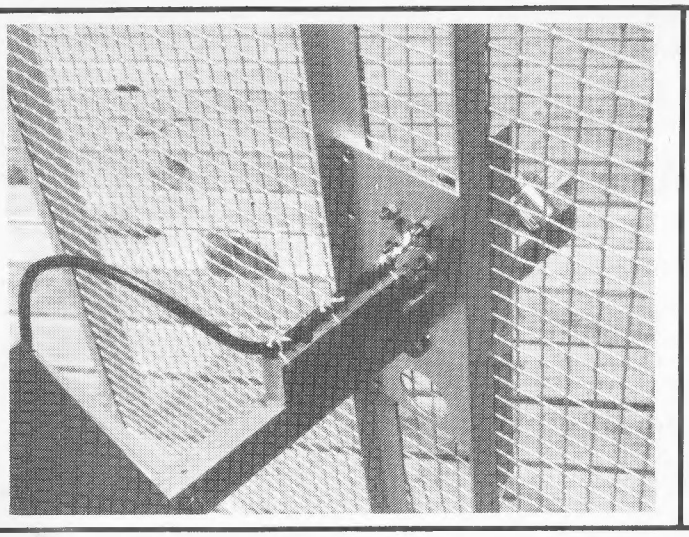


PHOTO 2: Termination of helix and mounting bracket and reflector (see also FIGURE 2).

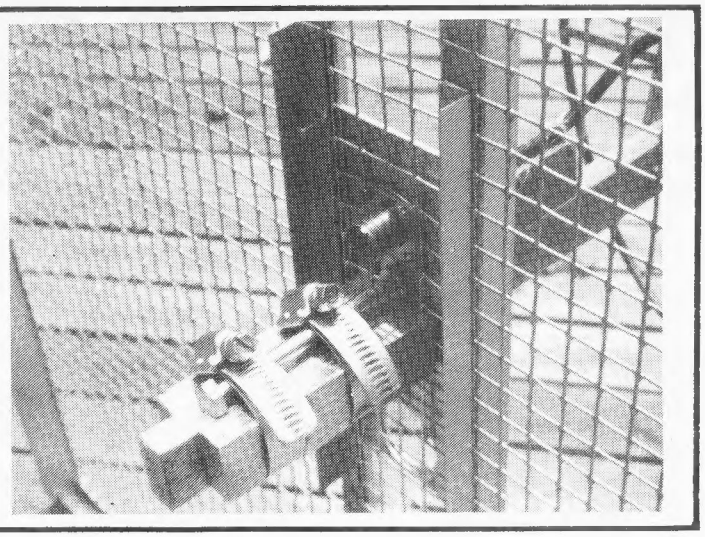
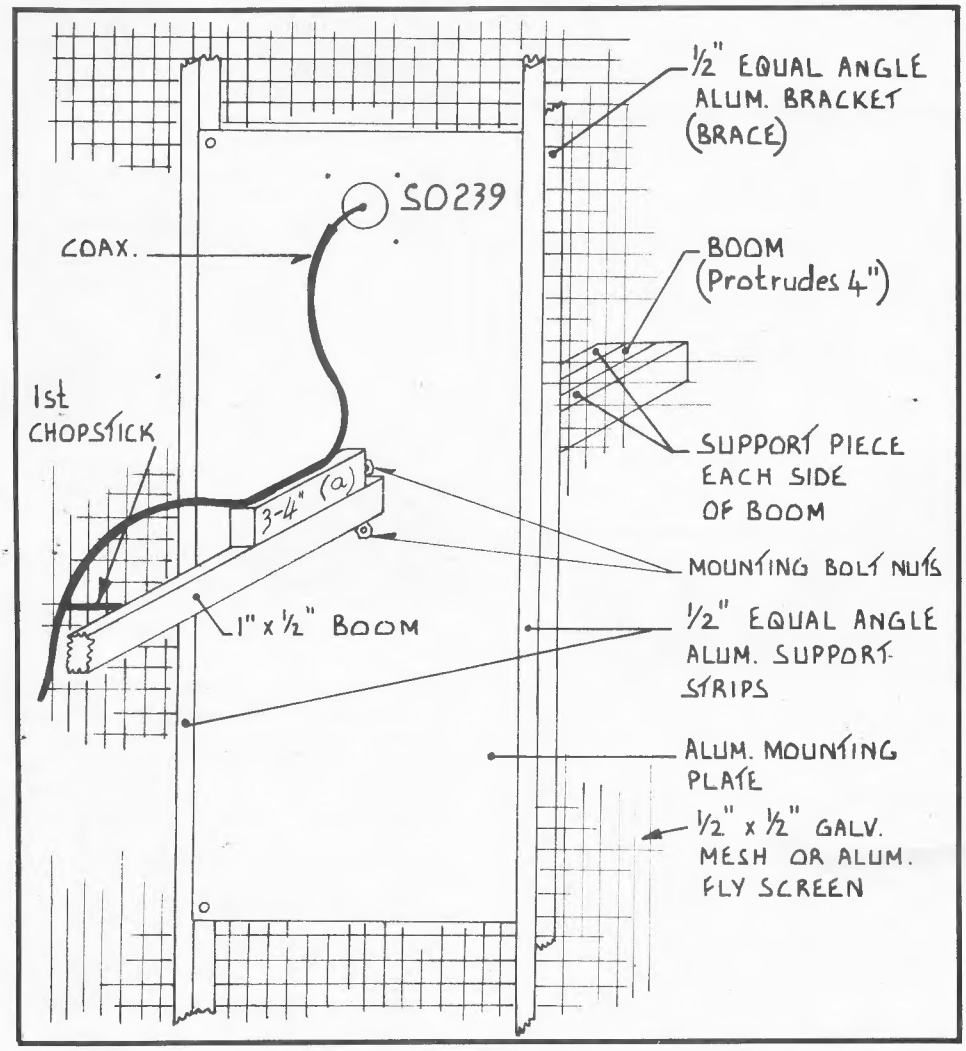


PHOTO 3: Securing the boom to the reflector (see also FIGURE 5).

and the 1.7 in. intervals were measured from this. All this can be seen clearly from the diagram.

A drop of glue was put into each drilled hole, and the chopsticks were pushed in one by one until they wedged tight. We did a double-check to make sure that we were putting them in with a clockwise spiral, as viewed from the reflector forward (that is, from the back of the beam). When giving the final push, each chopstick was twisted so that the square sides were roughly in line with the path that the RG58 helix would take. This made it easier to file a small U-shaped depression in the top, to allow the RG58 to sit in neatly. Chopsticks are generally about 10 inches long, and when pushed through the boom about 4 inches protruded on the other side. These bits were carefully sawn off. The helix diameter is 9 inches, so a mark was made on the last 4 spacers at each end of the boom, at a point 4½ inches from the centre-line of the boom. A fine hole was drilled at these marker points, and thread strung along from first to last spacer in each of the 4 rows. This enabled the other spacers to be marked, to show where they should be cut off. After trimming, the tops were filed into a U-shaped depression in line with the helix path. A small hole was then drilled, an eighth of an inch below the tip, so that a piece of waxed thread could be used to bind the RG58 helix in place.

FIGURE 2 (below): Details of mounting bracket on reflector (front view).



One end of the 25 foot length of RG58 was bared for half an inch, the sheath and dielectric removed, and the screen and centre conductor twisted together and soldered. Starting with this end, the RG58 was bound to the short straight end section (3.4 inches) next to the reflector position. The soldered tip was placed so that it would mate with the centre terminal of an SO-239 socket which would be mounted on the back of the reflector. The RG58 helix was then wound carefully around the spacers, one at a time, binding in each spacer before moving to the next. In this way it was possible to ensure that an even, circular spiral was created — with no bulges or flat sections. As we neared the tenth turn, there was about 8 inches of RG58 surplus. This was cut off, the end trimmed, and the outer screen and inner

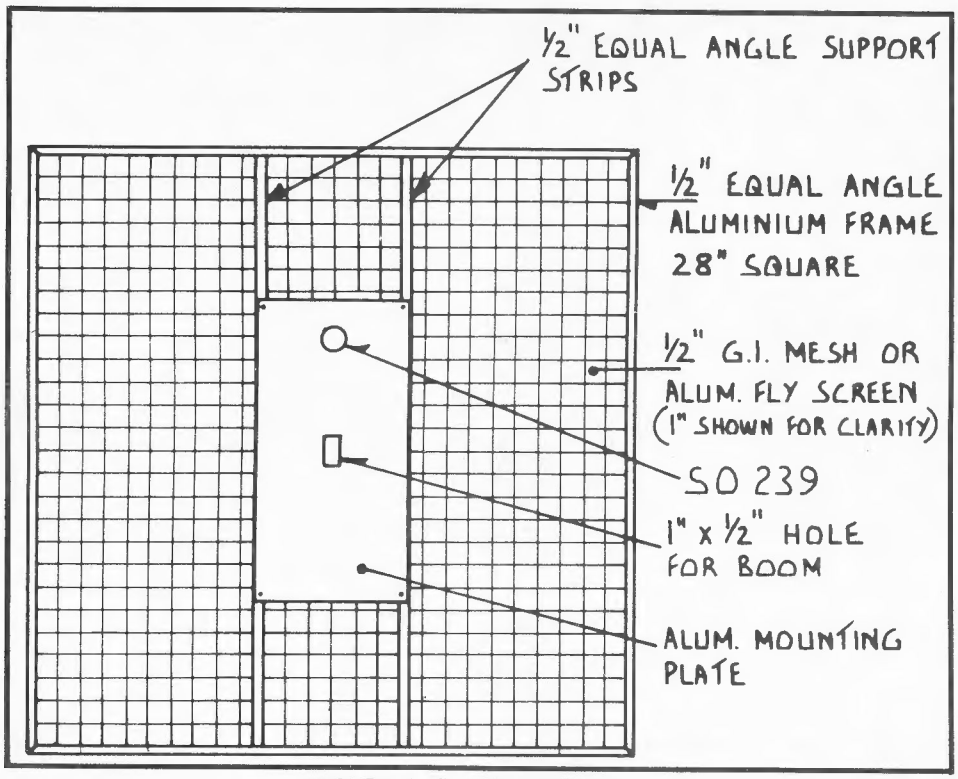


FIGURE 3: Details of reflector.

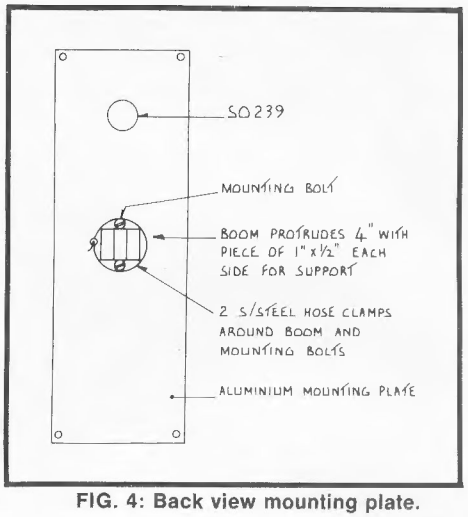


FIG. 4: Back view mounting plate.

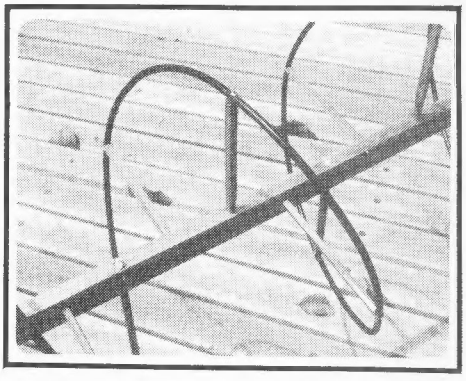


PHOTO 4: Helix attached to the "Chopsticks" spacers.

conductor soldered together as at the start ot fhe helix. The thread bindings were touched with glue, and the boom and chopsticks given a coat of clear varnish and set aside to dry.

The reflector came next. Half-inch squared mesh GI screen was used, and a 28-inch square cut out and edged with ½ by ½ aluminium angle. A small, sturdy aluminium plate was used as a centre mount for the reflector (it was, in fact, an old door-lock plate!). An aperture 1 by ½ inch was cut in the centre to allow the boom end to fit through and protrude 4 inches on the other side of the reflector. Above and below this aperture a hole was drilled for a 3-inch by ¼-inch coach bolt. The bolts were firmly screwed to the plate, with most of their length also protruding to the rear of the reflector. Two more lengths of aluminium angle (½ by ½) were screwed across the plate in a vertical direction, to make the reflector rigid. The SO-239 socket was fitted to the plate, facing rearwards, with its centre terminal lined up with the end of the helix at section "a". The antenna boom was then pushed through the reflector mounting plate, carefully squared up, and fixed firmly in place with two stainless steel hose clips around coach bolts and boom. The reflector weighed about 8 pounds, whereas the antenna-plus-boom was only 2 pounds. A plywood bracket was therefore fitted at the balance point, just a few inches from the reflector. Minor dents in the RG58 helix were pushed gently into shape, and the Ten-Turn "Chopstick" Helical was ready for hoisting aloft! Almost ready — that is.

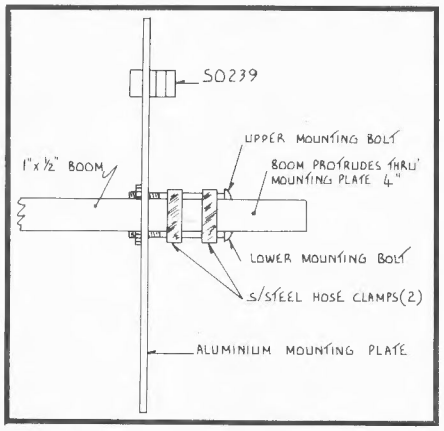


FIG. 5: Side view mounting plate.

There still remained the question of matching to a 50-ohm feeder. The feed impedance of a helical antenna of this design is near enough 140 ohms (this stays the same, by the way, regardless of the number of turns in the helix). A quarter-wave matching section should therefore have an impedance of about 84 ohms. The nearest coax is RG62, which has an impedance of 93 ohms. A quarter wavelength at 435 MHz is 6.8 inches and the velocity factor brings this down to 5.7 inches (there's a trap here: solid dielectric coax like RG8 or RG58 has a velocity factor of 0.66, but RG62 is partly air-spaced and the factor is 0.84). After many 'cuts and tries", the SWR was brought down to 1 : 1.1. So this time the antenna

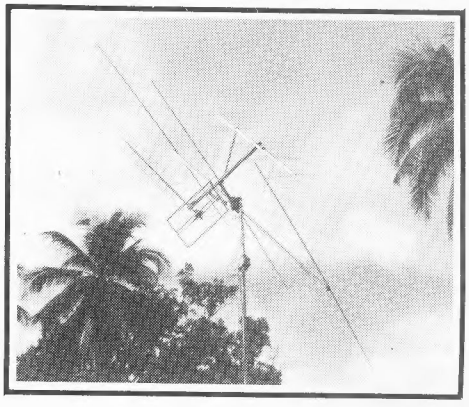


PHOTO 5: Final installation.

was really hoisted in the air and put to work. Results? When used as an Uplink antenna on Oscar 7, Mode B, signal reports have been encouraging: downlink on Mode J I can copy stations right down to the horizon. I think it works! ■

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